SOIL MOISTURE LEVELS - 1995
OLDMAN RIVER DAM

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Background

In 1989-1990 an extensive study was designed and initiated to investigate the effects of snow fences on the recovery of heavily grazed mixed-grassland on the land base surrounding the Oldman River Dam. The original purpose of the study was to monitor changes in plant growth and community composition to determine if placement of snow fences was beneficial to grassland recovery and if shrub thickets (used by wildlife for shelter) could be encouraged by increasing soil moisture. In 1990 a second component was added with the intent of tracking changes in soil moisture.

The purpose of this report is to provide preliminary analysis of soil moisture data collected in 1995 from this site.

Methods

A barbed-wire fence (approximately 300 metres) was installed in a WNW-ESE direction in an area of relatively flat, heavily grazed rangeland. The designed experiment consisted of four blocks each consisting of 70 metres of fences; half of which was covered with snow fence and half was left as a control (Figure 1). Moisture tubes were placed in 1990. Tubes were placed at distances of 2, 4, 8, 12, 16, 24, and 32 metres from the fence to a depth of 120 cm. Soil moisture data were collected in 1990 in mid summer and fall using a Campbell Pacific (503) Moisture Gauge (Smreciu and Hobden 1992). Data were also collected in fall of 1993, 1994, and summer of 1995.

Moisture measurements were taken to determine if snow fences affected soil moisture at various distances to the lee side and windward of the fence, and at various depths. We also wanted to determine if increases in soil moisture were retained from year to year.

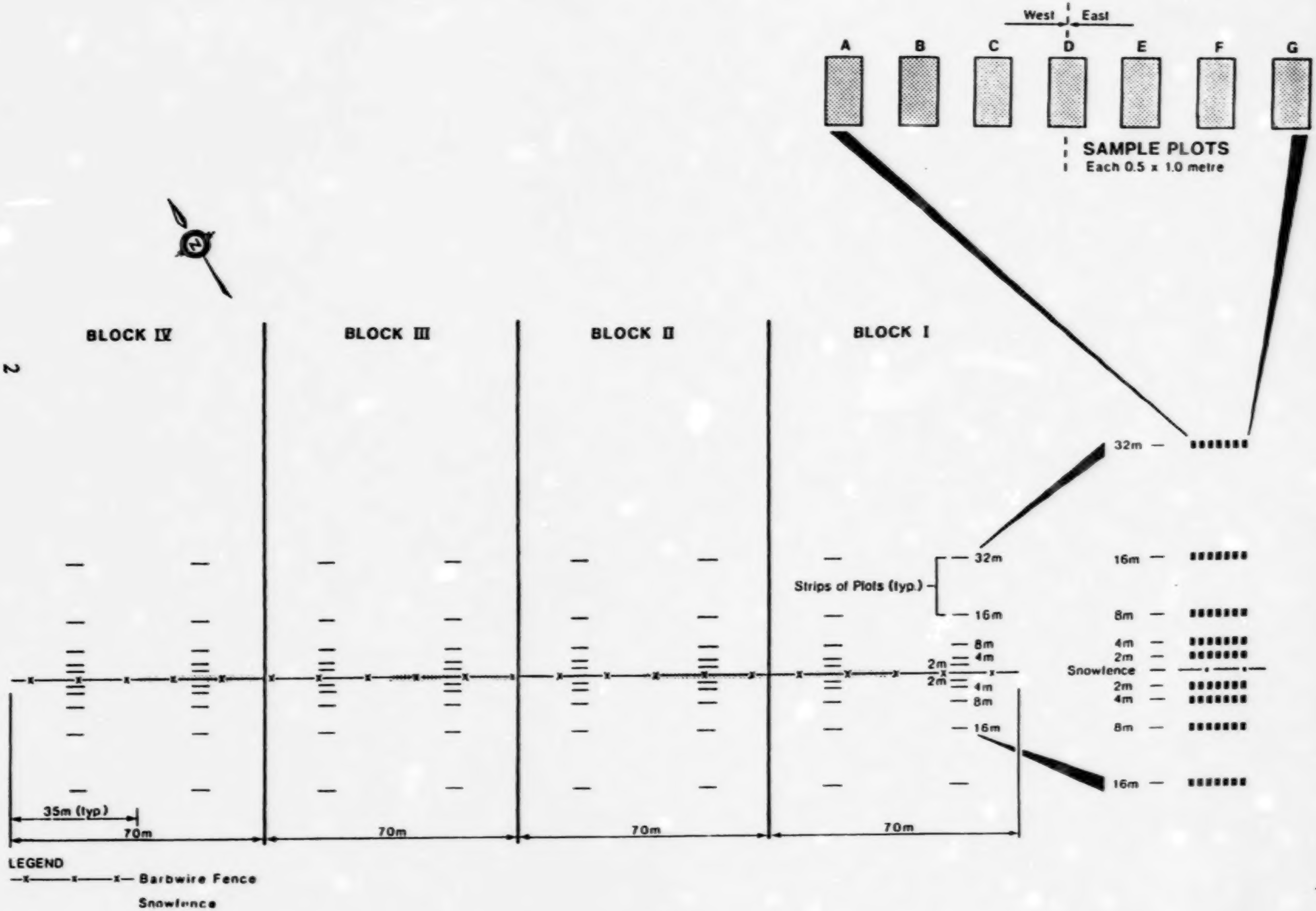
In 1993 and 1994 soil moisture was measured in late fall just prior to freeze up. Data from 1995 were collected in early July as part of a project to compare soil moisture monthly from spring through fall. Because of the constant precipitation in 1995, only the July results were completed.

Leeward and windward data for 1993, 1994 and 1995 were analysed independently using two-way ANOVA's (comparing fenced and controls at each distance/depth) and Duncan's Multiple Means Tests (SAS 1988).

Results

Results of 1990 were presented by Smreciu and Hobden (1992) and are summarized here. They concluded that soil moisture varied between summer and fall. Because the greatest amount of moisture was deposited in late spring and early summer, summer moisture levels were greater

Figure 1. Field design of experiment to determine effects of snow fence on soil moisture (from: Smreciu and Hobden 1992).



than fall levels, particularly at shallow depths. Similar moisture was recorded at a depth of 90 cm during both seasons. In summer, differences between snow fenced and control plots were not as pronounced as they were in the fall. As conditions became drier, more moisture was retained in snow fenced areas, particularly at greater depths. Soil moisture level is naturally much less variable at greater depths, particularly below the rooting depth. Soil moisture measurements taken in summer reflect seasonal precipitation whereas those taken in fall (and/or spring) would more likely reflect the retained moisture.

In the fall 1990, soil moisture was greater on the leeward side of the fence than on the windward side. Differences between control and snow fenced areas were observed both leeward and windward of the fence. The greatest increases in soil moisture on the windward side were observed at two to four metres from the fence. Snow fences increased moisture particularly at depths of 60-75 cm and 90-105 cm. On the lee side, soil moisture also increased with depth. Distance was only significant at a depth of 90-105 and the greatest soil moisture was observed at two to eight metres from the fence.

One of the interesting observations (with soil data and with productivity data) was that controls on the lee side of the fence were significantly different than controls on the windward side in 1990. The control plots on the windward side were drier suggesting that snow fences were not separated by sufficient distance to eliminate their influence leeward of the fence. Therefore, for the purpose of these analysis (for data from 1993, 1994 and 1995) only controls from the windward side were used.

Tables 1 and 2 present a summary of 1993, 1994, and 1995 moisture data at each of three depths at five distances. Appendix 1 lists the F test and probabilities of each of the analyses.

Generally soil moisture levels recorded in 1994 were much lower than from either 1993 or 1995 due to higher precipitation levels during the latter two years. Moisture content was highest in 1995 because monitoring was carried out during rainy period.

Directional effects.

Although we didn't analyse data to directly compare leeward and windward results, Figures 2 and 3 show that moisture is generally higher on the leeward side particularly during drier periods (1994).

Effects of snow fences.

Leeward. Leeward results for 1993, 1994, and 1995 are presented in Table 1.

In 1993, moisture content was relatively high and although there was a trend toward higher soil moisture behind the fences there were no significant differences between fenced and controls at any distance/depth. An anomaly was observed at 90 cm 32 m from the fence where the control moisture was greater.

In 1994, again there was a tendency for greater moisture behind the fences however most of the comparisons were not significant. Closer to the fence significant differences were observed at shallow depths (30 and 60 cm at 2 m and 30 cm at 4 m). This indicates that during dry periods the snow fence may delay the loss of surface moisture likely by diverting and slowing the wind or by shading these areas. At greater distances the significant differences were observed

Table 1. Soil moisture levels from snow fenced and control areas at various distances to the lee of the fenceline, at three depths. Results for three years are presented. For each pair of numbers the upper is the snow fenced treatment; the lower is for the control. Pairs that are printed in bold type are significantly different at $P \geq 0.05$.

Distance (m)	Depth (cm)	Soil Moisture (%)		
		1993 - fall	1994 - fall	1995 - summer
2	30	42.49 39.80	**24.92** **18.88**	45.98 45.64
	60	43.12 41.51	**28.62** **20.44**	44.14 45.60
	90	44.56 41.39	32.13 22.55	43.87 45.16
4	30	41.50 40.68	**23.93** **19.19**	45.34 45.75
	60	41.35 40.96	26.72 23.45	42.21 44.66
	90	42.27 40.28	31.66 29.60	42.38 42.87
8	30	40.34 39.91	24.39 21.32	45.32 45.89
	60	40.89 40.09	29.04 26.13	44.02 44.47
	90	41.67 40.24	**32.35** **29.28**	42.97 44.51
16	30	41.84 40.90	22.35 20.17	44.68 46.18
	60	42.78 40.31	26.80 23.38	44.60 45.48
	90	41.74 38.53	**30.95** **24.86**	43.61 42.95
32	30	42.40 40.44	23.51 20.95	44.97 46.15
	60	43.43 38.17	**26.08** **21.82**	45.34 44.15
	90	**40.58** **41.07**	29.28 24.70	42.90 43.97

Table 2. Soil moisture levels from snow fenced and control areas at various windward distances from the fenceline, at three depths. Results for three years are presented. For each pair of numbers the upper is the snow fenced treatment; the lower is for the control. Pairs that are printed in bold type are significantly different at P≥0.05.

Distance (m)	Depth (cm)	Soil Moisture (%)		
		1993 - fall	1994 - fall	1995 - summer
2	30	**43.89**	24.10	47.45
		39.80	18.88	45.64
	60	**43.86**	25.97	45.05
		41.51	20.44	45.60
	90	**45.49**	36.25	45.53
		41.39	22.55	45.16
4	30	42.00	**21.56**	45.77
		40.68	**19.19**	45.74
	60	43.10	25.51	44.43
		40.96	23.45	44.66
	90	42.88	29.34	44.09
		40.28	29.60	42.87
8	30	42.16	21.64	45.25
		39.91	21.32	45.89
	60	41.51	26.59	43.60
		40.09	26.13	44.47
	90	39.64	29.52	41.10
		40.24	29.28	44.51
16	30	41.70	22.48	45.79
		40.90	20.17	46.18
	60	41.22	25.94	43.08
		40.31	23.38	45.48
	90	40.70	28.17	42.73
		38.53	24.86	42.95
32	30	**42.76**	21.33	46.22
		40.44	20.95	46.15
	60	42.59	24.60	45.67
		38.17	21.82	44.15
	90	43.71	28.22	44.42
		41.07	24.70	43.97

at greater depths. At 8 and 16 m from the fenceline, differences were more pronounced at greater depths likely due to retention of moisture from snow catch in the previous winter. Snow catchment is greatest at 2 to 4 metres from the fenceline and the pile of snow tapers off to (and slopes toward) 8-16 metres. As the snow melts, it melts first at the edges and moisture can begin to penetrate the soil. Melt water also runs off the snow pile to these distances resulting in a greater accumulation over a longer period. Two and four metres is the last place where the snow melts and therefore moisture has less time to penetrate to greater depths.

In 1995, no significant differences were observed between snow fenced and control plots at any distance/depth. These observations are likely attributable to the great amounts of precipitation during the period leading up to data collection. The high precipitation also explains the observation that moisture was generally greater closer to the surface at almost all distances analysed.

Windward. Windward results for 1993, 1994, and 1995 are presented in Table 2.

In 1993 there was generally greater soil moisture where snow fences had been placed but most results were not significant except those close to the fence. There was significantly more moisture due to snow fence at all depths close to the fence (2 m). This was likely due to a combination of retained moisture from snow accumulation in this area from the previous winter, and may have been enhanced by runoff from snow accumulated on the leeward side of the fence because of the very gradual slope toward the windward direction. The effect of the fence in the reduction of moisture loss may also have been a contributing factor. At 32 m, significantly greater moisture was recorded in snow fenced plots but only at the shallow depth (30 cm). This too could be a result of moisture moving down slope.

In 1994, there was generally higher soil moisture in snow fenced plots than in control plots but results were not significant. Significantly greater moisture was recorded in snow fenced plots than in the control at 4 m/30 cm. Greater soil moisture was observed at greater depths.

In 1995, no significant differences in soil moisture levels were observed between snow fence and control plots at any distance/depth. These results were expected; 1990 data indicated that during this period (when precipitation is at its maximum) moisture levels were not affected by snow fences as greatly as they were when precipitation was lower. Precipitation levels in late spring and summer (1995) were very high (up to 3.5 times greater than normals for that period) (Environment Canada 1995). Average soil moisture ranged from 42.9% to 46.2%. Generally, greater amounts of moisture were observed at shallower depths. Again this was likely due to recent, heavy precipitation.

Summary

A trend toward greater soil moisture on the leeward side of the fence was noted and was more obvious when soil moisture levels were low.

Although statistical analyses do not indicate consistent significant differences in soil moisture between snow fenced and control plots, there was a trend toward higher soil moisture where snow fences were placed this was particularly evident during drier periods such as those observed in 1994.

Results of 1993-1995 indicate that soil moisture is not necessarily retained (at least above 90 cm) from year to year; soils can lose much of the retained moisture at these depths in dry years. To further understand the changes in moisture levels it would be of interest to track soil moisture throughout the growing season following a very wet year such as 1995.

References

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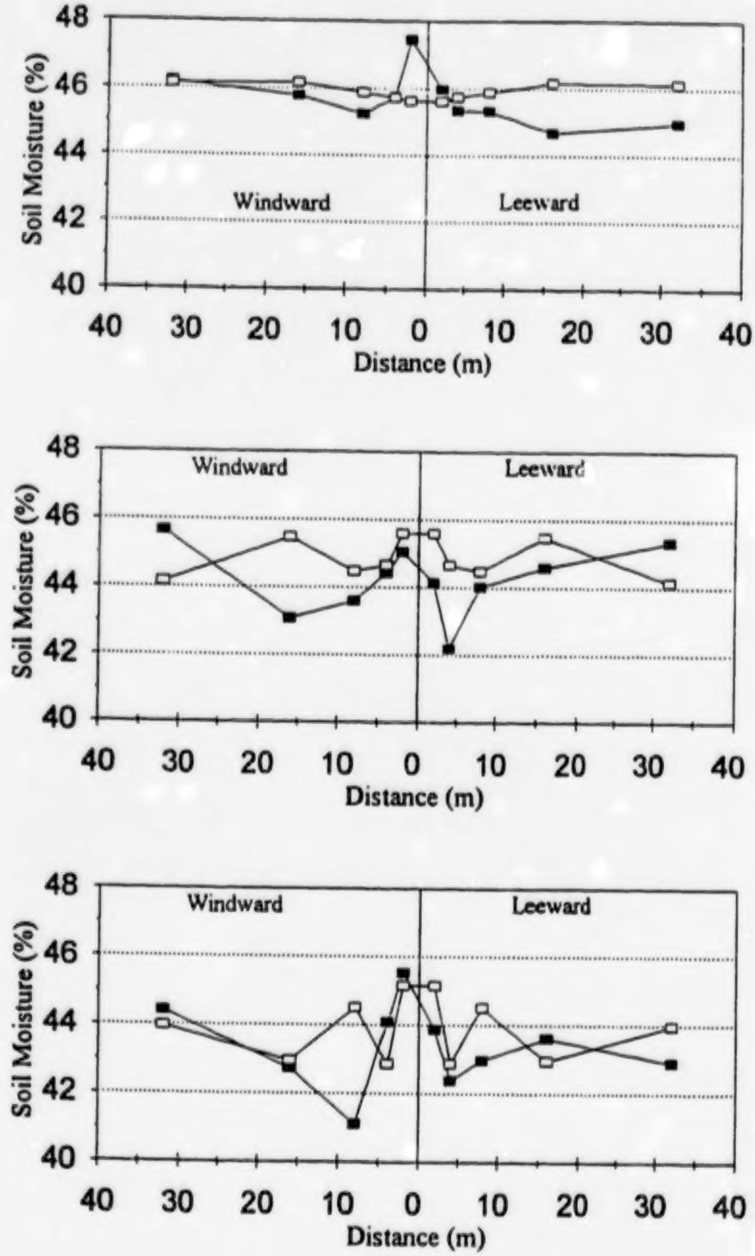
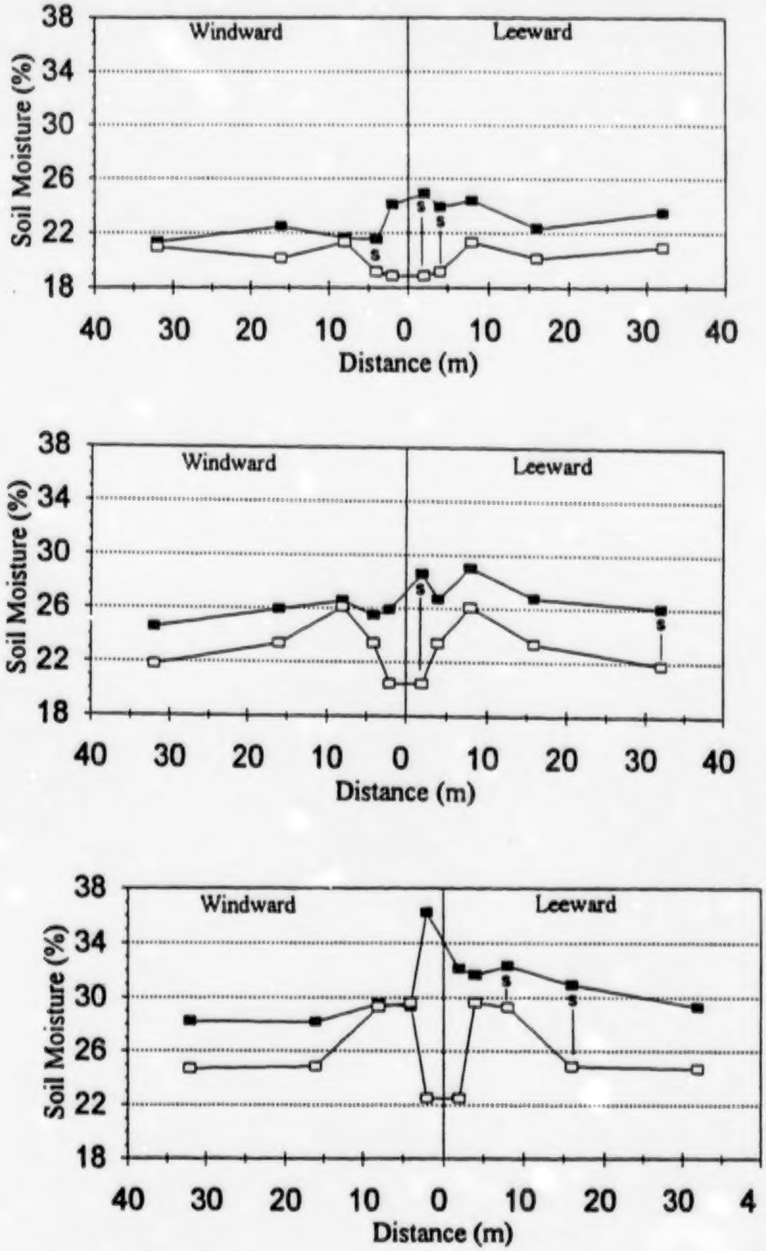
Figure 2. Soil moisture levels in July 1995 at 30 cm (top), 60 cm (middle), and 90 cm (bottom). Filled marks represent the snow fence treatment whereas open marks represent the controls.



There are no significant differences between control and snow fence moisture at any distance or depth.

Figure 3. Soil moisture levels in fall 1994 at 30 cm (top), 60 cm (middle), and 90 cm (bottom). Filled marks represent the snow fence treatment whereas open marks represent the controls.



Significantly different data pairs are denoted with an 's'.

Appendix 1a. ANOVA sums of squares, F-values and probabilities for 1993 soil moisture levels from snow fenced and control areas at various . distances/depths leeward and windward of the fenceline. Refer to Table 1 for leeward values and Table 2 for windward values. Bold type indicates significance at $P \geq 0.05$.

Distance (m)	Depth (cm)	1995		
		Anova SS	F-Value	Pr>F
Leeward				
2	30	14.391	3.24	0.1698
	60	5.168	0.39	0.5782
	90	20.003	0.94	0.4037
4	30	1.312	0.17	0.7042
	60	0.304	0.02	0.8874
	90	6.749	0.18	0.7141
8	30	0.312	0.41	0.5888
	60	1.099	0.20	0.6997
	90	3.489	0.36	0.6109
16	30	1.758	0.20	0.6875
	60	12.276	2.15	0.2390
	90	20.608	3.05	0.1790
32	30	8.040	2.54	0.2093
	60	55.230	7.26	0.0741
	90	0.360	100000	**0.0001**
Windward				
2	30	28.688	100000	**0.0001**
	60	9.487	100000	**0.0001**
	90	22.386	100000	**0.0001**
4	30	11.258	1253.74	**0.0001**
	60	9.095	1.01	0.3890
	90	13.520	2.49	0.2129
8	30	10.125	2.59	0.2057
	60	4.004	0.35	0.5935
	90	0.732	0.03	0.8637
16	30	1.272	0.73	0.4545
	60	1.665	0.47	0.5420
	90	9.418	1.26	0.3435
32	30	10.811	14.80	**0.0310**
	60	39.117	7.57	0.0707
	90	11.918	1.73	0.3186

Appendix 1b. ANOVA sums of squares, F-values and probabilities for 1994 soil moisture levels from snow fenced and control areas at various distances/depths leeward and windward of the fenceline. Refer to Table 1 for leeward values and Table 2 for windward values. Bold type indicates significance at P≥0.05.

Distance (m)	Depth (cm)	1995		
		Anova SS	F-Value	Pr>F
Leeward				
2	30	73.023	21.41	**0.0190**
	60	133.661	53.99	**0.0052**
	90	157.331	10.22	0.0855
4	30	44.840	15.90	**0.0282**
	60	21.386	3.72	0.1494
	90	6.386	0.56	0.5914
8	30	14.168	3.26	0.2126
	60	12.673	8.23	0.1031
	90	11.322	100000	**0.0001**
16	30	9.505	0.60	0.4934
	60	23.35	2.12	0.2417
	90	63.701	100000	**0.0001**
32	30	13.133	9.17	0.0564
	60	36.338	11.05	**0.0449**
	90	13.954	-	-
Windward				
2	30	46.741	3.50	0.2024
	60	52.440	7.31	0.1138
	90	140.768	-	-
4	30	11.258	1253.74	**0.0001**
	60	8.426	1.36	0.3274
	90	0.099	0.01	0.9444
8	30	0.174	0.03	0.8798
	60	4.004	0.35	0.5935
	90	0.0768	0.00	0.9650
16	30	10.672	2.09	0.2439
	60	13.132	1.03	0.3851
	90	21.912	3.73	0.1491
32	30	0.2926	0.21	0.6813
	60	15.429	0.62	0.4872
	90	9.275	-	-

Appendix 1c. ANOVA sums of squares, F-values and probabilities for 1995 soil moisture levels from snow fenced and control areas at various distances/depths leeward and windward of the fenceline. Refer to Table 1 for leeward values and Table 2 for windward values. Bold type indicates significance at P≥0.05.

Distance (m)	Depth (cm)	1995		
		Anova SS	F-Value	Pr>F
Leeward				
2	30	0.228	0.07	0.8138
	60	4.278	0.57	0.5048
	90	2.849	0.41	0.5869
4	30	0.336	0.23	0.6667
	60	10.283	3.45	0.2043
	90	0.412	0.15	0.7361
8	30	0.487	0.11	0.7717
	60	0.304	0.66	0.5016
	90	3.542	3.92	0.1863
16	30	4.530	2.88	0.1883
	60	1.540	1.40	0.3215
	90	0.852	0.97	0.3968
32	30	2.761	0.60	0.4961
	60	2.856	2.65	0.2019
	90	1.374	0.70	0.5574
Windward				
2	30	5.637	1.54	0.3404
	60	0.520	0.26	0.6610
	90	0.232	0.11	0.7714
4	30	0.001	0.00	0.9876
	60	0.108	0.02	0.9078
	90	2.977	0.58	0.5009
8	30	0.715	0.06	0.8237
	60	1.308	0.12	0.7581
	90	19.992	5.46	0.1445
16	30	0.312	0.81	0.4344
	60	11.520	2.96	0.1839
	90	0.099	0.03	0.8670
32	30	0.010	0.00	0.9657
	60	4.590	0.55	0.5128
	90	0.299	0.11	0.7947